

Claims

What is claimed is:

5

1. Method for monitoring the stability of the carrier frequency (ω_i) of identical transmitted signals ($s_i(t)$) of several transmitters ($S_1, \dots, S_i, \dots, S_n$) of a single-frequency network by evaluating the phase position of a received signal ($e_i(t)$) associated with a transmitted signal ($s_i(t)$) of a transmitter (S_i) with reference to a received signal ($e_0(t)$) of a reference transmitter (S_0), both of which are received by a receiver device (E) positioned within the transmission range of the single-frequency network.

15

2. Method according to claim 1,
characterised by

20

25

30

a calculation (S_{70}) of a carrier-frequency displacement ($\Delta\omega_i$) of a carrier frequency (ω_i) of a transmitter (S_i) relative to a reference carrier frequency (ω_0) of the reference transmitter (S_0) from a phase-displacement difference ($\Delta\Delta\Theta_i(t_{B2}-t_{B1})$) caused by the carrier-frequency displacement ($\Delta\omega_i$) of this transmitter between a phase displacement ($\Delta\Theta_i(t_{B2})$) at least at one second observation time (t_{B2}) and a phase displacement ($\Delta\Theta_i(t_{B1})$) at a first observation time (t_{B1}) of a received signal ($e_i(t)$) of this transmitter (S_i) associated with the transmitted signal ($s_i(t)$) relative to a received signal ($e_0(t)$) of the reference transmitter (S_0) associated with the transmitted signal ($s_0(t)$).

3. Method for monitoring the stability of the carrier frequency according to claim 2,

characterised in that

the calculation (S70) of the carrier-frequency displacement ($\Delta\omega_i$) of the carrier frequency (ω_i) of the transmitter (S_i) relative to the carrier frequency (ω_0) of the reference transmitter (S_0) from the phase-displacement difference ($\Delta\Delta\Theta_i(t_{B2}-t_{B1})$) is preceded by the procedural stages listed below:

- determination (S10) of a transmission function ($H_{SFN}(f)$) of the transmission channel from the transmitters ($S_1, \dots, S_i, \dots, S_n$) to the receiver device (E),
- calculation (S20) of a characteristic of a complex, time-discrete, summated impulse response ($h_{SFN1}(t)$) at the first observation time (t_{B1}) and a characteristic of a complex, time-discrete, summated impulse response ($h_{SFN2}(t)$) at the second observation time (t_{B2}) of the transmission channel respectively from the transmission function ($H_{SFN}(f)$) of the transmission channel,
- masking (S30) of a characteristic of a complex impulse response ($h_{SFN1i}(t)$) at the first observation time (t_{B1}) and of a characteristic of a complex impulse response ($h_{SFN2i}(t)$) at the second observation time (t_{B2}) for every transmitter (S_i) of the single-frequency network respectively from the characteristic of the complex, summated impulse response ($h_{SFN1}(t)$) at the first observation time (t_{B1}) and from the characteristic of the complex,

summated impulse response ($h_{\text{SFN2}}(t)$) at the second observation time (t_{B2}),

5 - determination (S40) of a phase characteristic ($\arg(h_{\text{SFN1i}}(t))$) of the complex impulse response ($h_{\text{SFN1i}}(t)$) at the first observation time (t_{B1}) and of a phase characteristic ($\arg(h_{\text{SFN2i}}(t))$) of the complex impulse response ($h_{\text{SFN2}}(t)$) at the second observation time (t_{B2}) for every transmitter (S_i) of the single-frequency network,

10 - calculation (S50) of the phase-displacement difference ($\Delta\Delta\Theta_i(t_{\text{B2}}-t_{\text{B1}})$) between a phase displacement ($\Delta\Theta_i(t_{\text{B2}})$) at the second observation time (t_{B2}) and a phase displacement ($\Delta\Theta_i(t_{\text{B1}})$) at the first observation time (t_{B1}) by subtraction of a phase characteristic ($\arg(h_{\text{SFN1i}}(t))$) of the complex impulse response ($h_{\text{SFN1i}}(t)$) at the first observation time (t_{B1}) from a phase characteristic ($\arg(h_{\text{SFN2i}}(t))$) of the complex impulse response ($h_{\text{SFN1i}}(t)$) at the second observation time (t_{B2}) of the respective transmitter (S_i).

4. Method for monitoring the stability of the carrier frequency according to claim 3,

characterised by

30 - increasing (S60) the phase-displacement difference ($\Delta\Delta\Theta_i(t_{\text{B2}}-t_{\text{B1}})$) by the factor $2*\pi$ in the case of a decrease in the phase-displacement difference ($\Delta\Delta\Theta_i(t_{\text{B2}}-t_{\text{B1}})$) to the value $-\pi$ or below and

35 - reducing (S65) the phase-displacement difference ($\Delta\Delta\Theta_i(t_{\text{B2}}-t_{\text{B1}})$) by the factor $-2*\pi$ in the case of an

increase in the phase-displacement difference
 $(\Delta\Delta\Theta_i(t_{B2}-t_{B1}))$ above the value π .

5. Method for monitoring the stability of the carrier
 5 frequency according to claim 3 or 4,
characterised in that
 in the case of digital terrestrial TV, the
 transmission function of the transmission channel
 from the transmitters $(S_1, \dots, S_i, \dots, S_n)$ to the receiver
 10 device (E) is determined from the DVB-T symbols of
 scattered pilot carriers of received signals $(e_i(t))$
 of the transmitters $(S_1, \dots, S_i, \dots, S_n)$ modulated
 according to the orthogonal-frequency-division-
 multiplexing (OFDM) method.
- 15
6. Method for monitoring the stability of the carrier
 frequency according to claim 3,
characterised in that
 the calculation (S20) of a characteristic of a
 20 complex, time-discrete, summated impulse response
 $h_{SFN1/2}(t)$ at the discrete first observation time t_{B1}
 of the transmission channel is derived from the
 transmission function $H_{SFN}(f)$ of the transmission
 channel using the Fourier transform according to
 25 the formula:

$$h_{SFN1/2}(t) = \sum_{k=0}^{N_F-1} H_{SFN}(k) * e^{j2\pi kt / N_F}$$

wherein

- 30 $H_{SFN}(f)$ denotes the transmission function or
 respectively the frequency response
 of the transmission channel,
 N_F denotes the number of sampling values
 for the discrete Fourier transform,

k denotes the discrete frequency values,
 t denotes the sampling times of the time-discrete, summated impulse response of the transmission channel and
 $1/2$ denotes the index for the observation time t_{B1} or respectively t_{B2} .

- 10 7. Method for monitoring the stability of the carrier frequency according to claim 6,
characterised in that
 the calculation (S50) of the phase-displacement difference ($\Delta\Delta\Theta_i(t_{B2}-t_{B1})$) for each transmitter S_i of
 15 the single-frequency network is derived according to the formula:

$$\Delta\Delta\Theta_i(t_{B2}-t_{B1}) = \arg(h_{SFN2i}(t)) - \arg(h_{SFN1i}(t))$$

20 wherein

i denotes the index for the transmitter S_i
 $\arg(h_{SFN2i}(t))$ denotes the phase characteristic of the complex impulse response $h_{SFN2i}(t)$
 25 at the observation time t_{B2} of the transmitter S_i and
 $\arg(h_{SFN1i}(t))$ denotes the phase characteristic of the complex impulse response $h_{SFN1i}(t)$
 at the observation time t_{B1} of the
 30 transmitter S_i .

8. Method for monitoring the stability of the carrier frequency according to claim 7,
characterised in that

the calculation (S70) of the carrier-frequency displacement $\Delta\omega_i$ of the transmitter S_i relative to the carrier frequency ω_0 of the reference transmitter of the single-frequency network is
 5 derived according to the formula:

$$\Delta\omega_i = \Delta\Delta\Theta_i(t_{B2}-t_{B1})/(t_{B2}-t_{B1})$$

wherein

10 i denotes the index for the transmitter S_i ,
 $\Delta\Delta\Theta_i(t_{B2}-t_{B1})$ denotes the phase position difference $\Delta\Delta\Theta_i(t_{B2}-t_{B1})$ for the transmitter S_i of the single-frequency network and
 15 t_{B1}, t_{B2} denote the observation times.

9. Method for monitoring the stability of the carrier frequency according to claim 8,

characterised in that

20 to allow an unambiguous identification of the permanent carrier-frequency displacement $\Delta\omega_i$ of the transmitter S_i in the single-frequency network relative to the carrier frequency ω_0 of the reference transmitter S_0 at several observation
 25 times t_{Bj} , the following procedural stages are implemented repeatedly:

- calculation (S20) of the characteristic of the complex, time-discrete, summated impulse response
 30 $h_{SFNj}(t)$ and $h_{SFN(j+1)}(t)$ at the observation times t_{Bj} and $t_{B(j+1)}$,

- masking (S30) of the characteristic of the complex impulse response $h_{SFNji}(t)$ and $h_{SFN(j+1)i}(t)$ at

the observation times t_{Bj} and $t_{B(j+1)}$ for every transmitter S_i of the single-frequency network,

- 5 - determination (S40) of the phase characteristics $\arg(h_{SFNji}(t))$ and $\arg(h_{SFN(j+1)i}(t))$ of the complex impulse responses $h_{SFNji}(t)$ and $h_{SFN(j+1)i}(t)$ at the observation times t_{Bj} and $t_{B(j+1)}$,
- 10 - calculation (S50) of the phase-displacement difference $(\Delta\Delta\Theta_i(t_{B(j+1)}-t_{Bj}))$ between the phase displacement $\Delta\Theta_i(t_{B(j+1)})$ at the observation time $t_{B(j+1)}$ and the phase displacement $\Delta\Theta_i(t_{Bj})$ at the observation time t_{Bj} for every transmitter S_i of the single-frequency network,
- 15 - increasing (S60) the phase-displacement difference $\Delta\Delta\Theta_i(t_{B(j+1)}-t_{Bj})$ by the factor $2*\pi$ in the case of a decrease in the phase-displacement difference $(\Delta\Delta\Theta_i(t_{B(j+1)}-t_{Bj}))$ to the value $-\pi$ or below,
- 20 - reducing (S65) the phase-displacement difference $(\Delta\Delta\Theta_i(t_{B(j+1)}-t_{Bj}))$ by the factor $-2*\pi$ in the case of an increase in the phase-displacement difference $\Delta\Delta\Theta_i(t_{B(j+1)}-t_{Bj})$ above the value π and
- 25 - calculation (S70) of the carrier-frequency displacement $\Delta\omega_{ij}$ of the transmitter S_i relative to the carrier frequency ω_0 of the reference transmitter of the single-frequency network at
- 30 several observation times t_{Bj} ;

and that following this, an averaging (S80) of all carrier-frequency displacements $\Delta\omega_{ij}$ of every

transmitter S_i relative to the carrier frequency ω_0 of the reference transmitter S_0 of the single-frequency network calculated respectively in procedural stage (S70), is implemented at the
 5 observation times t_{Bj} .

10. Method for monitoring the stability of the carrier frequency according to claim 9,

characterised in that

10 the averaging (S80) of all carrier-frequency displacements $\Delta\omega_{ij}$ of every transmitter S_i relative to the carrier frequency ω_0 of a reference transmitter S_0 of the single-frequency network calculated in procedural stage (S70), is
 15 implemented using a recursive method.

11. Device for monitoring the stability of the carrier frequency (ω_i) of identical transmitted signals $s_i(t)$ of several transmitters ($S_1, \dots, S_i, \dots, S_n$) of a
 20 single-frequency network comprising:

- a receiver device (E),
- a unit (11) for determining a transmission
 25 function $H_{\text{SFN}}(f)$ of a transmission channel of several transmitters ($S_1, \dots, S_i, \dots, S_n$) of the single-frequency network to the receiver device (E) disposed within the transmission range of the single-frequency network,
- 30 - a unit (12) for implementing an inverse Fourier transform,

- a unit (13) for masking a impulse response ($h_{SFNi}(t)$) for every transmitter (S_i) from the summated impulse response ($h_{SFN}(t)$),
- 5 - a unit (14) for determining the phase characteristic ($\arg(h_{SFNi}(t))$) of the impulse response ($h_{SFNi}(t)$) for every transmitter (S_i),
- a unit (15) for calculating the phase-
- 10 displacement difference ($\Delta\Delta\Theta_i(t_{B(j+1)}-t_{Bj})$) of the phase displacement ($\Delta\Theta_i$) of a transmitter (S_i) relative to a reference transmitter (S_0) at least at two different times ($(t_{B1}, -t_{Bj+1})$) and the carrier-
- 15 frequency displacement ($\Delta\omega_i$) of every transmitter (S_i) relative to the carrier frequency (ω_0) of the reference transmitter (S_0) and
- a unit (2) for presenting the calculated carrier-
- 20 frequency displacement ($\Delta\omega_i$) of every transmitter (S_i) relative to the carrier frequency (ω_0) of the reference transmitter (S_0) of the single-frequency network.
- 12. Device for monitoring the stability of the carrier
- 25 wave (ω_i) of identical transmitted signals $s_i(t)$ of several transmitters ($S_1, \dots, S_i, \dots, S_n$) of a single-frequency network comprising:
 - a receiver device (E),
 - 30 - a unit (16) for determining a transmission function ($H_{SFN}(f)$) from pilot carriers of the received signal ($e_i(t)$),

- a unit (13) for masking a impulse response ($h_{SFNi}(t)$) for every transmitter (S_i) from the summated impulse response ($h_{SFN}(t)$),
- 5 - a unit (14) for determining the phase characteristic ($\arg(h_{SFNi}(t))$) of the impulse response ($h_{SFNi}(t)$) for every transmitter (S_i),
- 10 - a unit (15) for calculating the phase-displacement difference ($\Delta\Delta\Theta_i(t_{B(j+1)}-t_{Bj})$) of the phase displacement $\Delta\Theta_i$ of a transmitter (S_i) relative to a reference transmitter (S_0) at least at two different times ($t_{Bj}-t_{B(j+1)}$) and the carrier-frequency displacement ($\Delta\omega_i$) of every transmitter
- 15 relative to the carrier frequency (ω_0) of the reference transmitter (S_0) and
- 20 - a unit (2) for presenting the calculated carrier-frequency displacement ($\Delta\omega_i$) of every transmitter (S_i) relative to the carrier frequency (ω_0) of the reference transmitter (S_0) of the single-frequency network.
- 25 13. Device for monitoring the stability of the carrier frequency according to claim 11 or 12,
characterised in that
the unit (2) for presenting the calculated carrier-frequency displacement ($\Delta\omega_i$) of every transmitter (S_i) relative to the carrier frequency (ω_0) of the reference transmitter (S_0) comprises a tabular
30 and/or graphic display device.